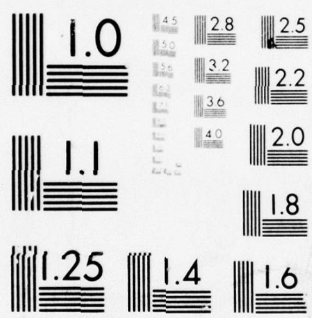
AD-A042 860 COAST GUARD RESEARCH AND DEVELOPMENT CENTER GROTON CONN F/G 17/7
THE DISTRESS ALERTING AND LOCATING SYSTEM (DALS). SUMMARY OF DE--ETC(U)
APR 77 J R LINDEBLAD

UNCLASSIFIED CGR/DC-6/77 USCG-D-29-77 NL

| OF | AD A042 860

END
DATE FILMED
9-77
DDC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Report No. CG-D-29-77

(14)

THE DISTRESS ALERTING AND LOCATING SYSTEM (DALS) SUMMARY OF DEVELOPMENT AND DOCUMENTATION

J. R. Lindeblad
U.S. Coast Guard Research and Development Center
Avery Point, Groton, Connecticut 06340

DEPARTMENT OF TRANSPORTATION
UNITED STATES OF AMERICA

April 1977

Final Report

Document is available to the U.S. public through
the National Technical Information Service,
Springfield, Virginia 22161

Prepared for

DEPARTMENT OF TRANSPORTATION
UNITED STATES COAST GUARD
Office of Research and Development
Washington, D.C. 20590

N O T I C E

D. L. Birkimer

Donald L. BIRKIMER, Ph.D., P.E.
Technical Director
U.S. Coast Guard Research and
Development Center
Avery Point
Groton, Connecticut 06340

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
18 US CG-D-29-77 19		11

4. Title and Subtitle	5. Report Date
6 THE DISTRESS ALERTING AND LOCATING SYSTEM (DALS). SUMMARY OF DEVELOPMENT AND DOCUMENTATION.	Apr[redacted]977 12 38p.
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) 10 J. R. Lindeblad	14 CGR/DC-6/77

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
U. S. Coast Guard Research and Development Center Avery Point Groton, CT 06340	761140
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered 9
Department of Transportation United States Coast Guard Office of Research and Development Washington, DC 20590	Final Rep[redacted]t. Jul[redacted]71—Sep[redacted] 1976
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report documents the evolution of a Distress Alerting and Locating System (DALS) based on the retransmission of radio navigational aid signals. This equipment, developed from balloon tracking and meterological data gathering equipment manufactured by Beukers Laboratories, progressed through a test and development cycle culminating in a system that could:

- automatically alert search and rescue forces of a distress situation
- identify the distressed vessel
- automatically indicate the distress site location to within 1/2 mile
- automatically plot the distressed vessel's location
- track multiple vessels simultaneously
- operate at extended ranges by using aircraft-mounted telemetry equipment

Ancillary developments include a VHF-FM marine-band distress beacon whose radio signal includes identification information, a plasma-display-based SAR Command and Control Console, and techniques for narrow-band retransmission of the Omega navigation system signals over a telemetry link.

Budgetary limitations and cost effectiveness studies resulted in termination of the DALS development prior to installation and testing of an operational system.

17. Key Words	18. Distribution Statement
Loran-C, Omega, navigational aids, search and rescue, retransmission, DALS	Document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	39	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

408 730

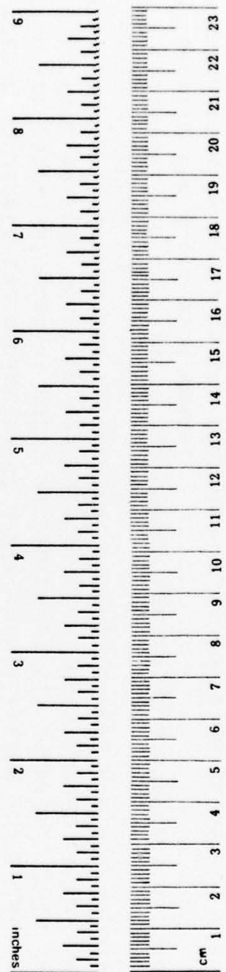
LB

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

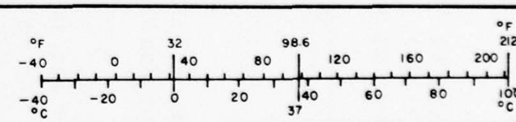


TABLE OF CONTENTS

Page

LIST OF FIGURES

List of Definitions and Abbreviations

AIDS - Automatic Identification and Distress System; a VHF-FM emergency beacon which generates distress tones and an identification signal which is received and decoded by the system decoder/display.

ASCII - American Standard Code for Information Interchange; a coded character set used for information processing.

Algorithm - a set of well-defined rules for the solution of a problem

Analog - data in the form of a continuously variable physical quantity

Alpha-numeric - a character set containing letters, numbers and symbols

Bit - binary digit; a single occurrence of a character in a lauguage employing exactly two distinct characters

FSK - Frequency Shift Keying; a form of frequency modulation in which the modulating wave shifts the output frequency between predetermined values, and the output wave has no phase continuity

LO-CATE - Loran OMEGA Course and Track Equipment, a group of meterological data gathering equipments

Loran-C - a low-frequency radionavigation system by which hyperbolic lines of position are determined by measuring the difference in time of reception of synchronized pulse signals from two fixed transmitters. Two or more intersecting hyperbolic lines can describe a position.

MSK - Minimum Shift Keying; a special form of FSK where the two frequencies are separated by exactly 1/2 the bit rate.

OMEGA - A worldwide radio navigation system providing moderate accuracy by phase comparison of very low frequency continuous wave radio signals

PSK - Phase Shift Keying; a digital modulation technique where one phase of the carrier represents one binary state and a second phase is used for the other state.

Plasma Display - a flat plate display device similar in capability to a Cathode-Ray-Tube but using a matrix of gas discharge cells to form the displayed information

Pre-operational - having the characteristics of an operational system but still under development.

Re-transmitter - a device used as an intermediate instrument for passing radio information from one point to another

ROM - Read Only Memory; a storage device which stores fixed data in binary form

SAR - Search and Rescue

TTL - Transistor-Transistor Logic; a logic form used in modern electronic circuits

Telemetry - transmission of information from one location to another by means of wires, radio waves or other media

VHF-FM Marine Band - a band of the radio frequency spectrum from approximately 150 to 174 MHz used for low power two-way mobile communications

VTS - Vessel Traffic Service

1. BACKGROUND

Search and Rescue (SAR) is one of the primary missions of the U.S. Coast Guard. In 1970 there were an estimated 7.5 million recreational boats in the United States with conservative estimates of 9 to 10 million by 1980. Since a large number of these boats operate in the ocean coastal areas, a large fraction of the Coast Guard's SAR activity takes place in these waters. During that year, the Coast Guard's Office of Research and Development established a project to investigate techniques to improve the Coast Guard's SAR capabilities. One phase of the project was the development of an improved system by which the recreational boating community could alert the Coast Guard to a distress situation, and be positively located by SAR units. The method would have to be accomplished by relatively inexpensive and direct techniques. Any solution would have to be semi-automatic, reliable and should involve hardware that was inexpensive for the user i.e., the recreational boating community. Several established techniques were considered candidate solutions to the problem and work was started to select one of them.

After an extensive selection process one system was chose for evaluation. In January, 1972 the Coast Guard contracted with Beukers Laboratories, Inc., for a LO-CATE® III system, modified for use as a Distress Alerting and Locating System (DALS), the operation of which is outlined below.

The basis for this system is the use by a recreational boater of a handheld radio-navigational signal retransmitting device (Figure 1). This device is the DALS retransmitter and is a combination receiver/transmitter. Although the mechanism to be used to put the retransmitter in the hands of the recreational boater was not part of the project, it was expected that the devices would be manufactured and made available through commercial retail outlets. A target cost of $100 for the retransmitter was established. The retransmitter receives both Loran-C and OMEGA radio-navigational aid (navaid) signals, then retransmits them with minimal processing. The retransmitter also generates an identification code and a distress alert signal, which along with the navaid information can be received and processed by a Coast Guard Station which is equipped with a DALS base station. The identification code is displayed to the base station operator to identify that retransmitter and that one alone as the one generating the signals. The distress alert signal is the International Two-Tone distress alert signal and gives an aural indication of the distress occurrence to the base station operator as well as anyone monitoring the telemetry frequency. The retransmitter broadcasts its signal directly to the Coast Guard Station or, if its location is below the radio

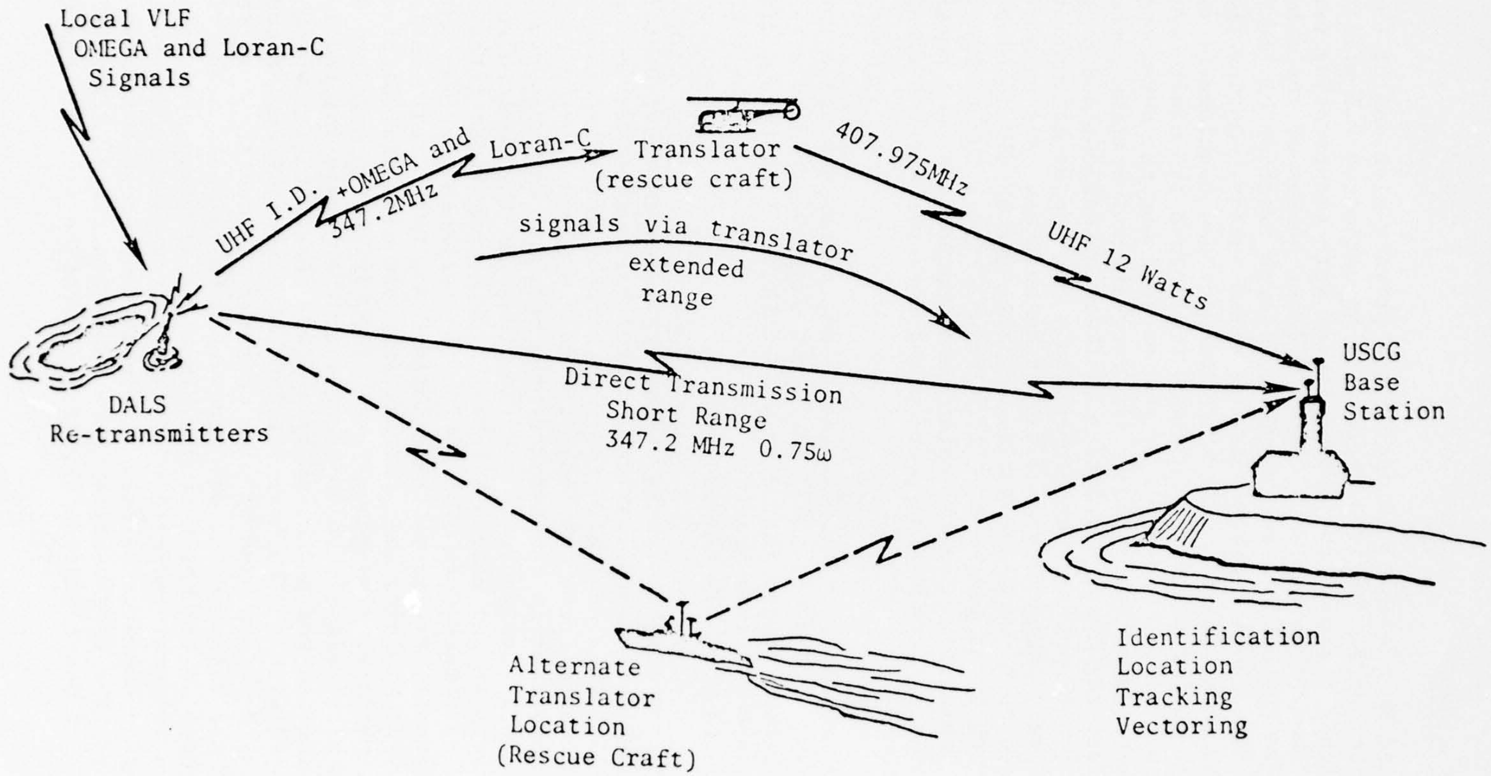


FIGURE 1 - DALS SYSTEM CONCEPT

horizon, via a secondary telemetry link. The secondary telemetry link uses a device called a translator, which can be tower mounted or carried aboard a rescue boat or aircraft. It extends the range of the DALS well beyond the normal line-of-site range of the DALS telemetry frequency. When the translator is installed in the rescue unit, it performs either the function of relaying the distressed vessel's retransmitter signal, or of retransmitting information regarding its own position, as selected by operating personnel.

The receiving equipment at the DALS base station is phase-locked to the locally received Loran-C and/or OMEGA signals and compares the differences in the time or phase of the locally and remotely received navaid signals to determine the retransmitter's location.

The DALS is designed to operate with 3-frequency OMEGA signals only, with Loran-C signals only, or with both, depending on the signals available and the specific capability selected.

The DALS project began as simply the test and evaluation of the modified LO-CATE® III system and slowly evolved into a major developmental project incorporating complex functional changes culminating in specifications for a system that would operate with the National VHF-FM Distress Communciations System.

2. DALS DEVELOPMENT

The major portion of CY1972 was spent in initial preparations. Included in the preparations were; selection of a test site, selection and training of test personnel, performance of acceptance tests and initial development of a test plan. The Coast Guard Research and Development Center (R&DC) at Avery Point, Groton, CT, was selected as the test site, and Naval Air Test Center at Patuxent River, MD, wrote the test plan under contract to the Coast Guard.

The prototype DALS hardware was accepted and initially installed at R&DC in November 1972. Difficulties with system software delivery forced return of some of the hardware to the contractor's plant for use in problem resolution. There was only one system in existence and the contractor did not have the capability of simulating certain hardware parts during software development. The equipment was returned to the Center in February 1973. Fully operational software was not delivered until July 1973, although some testing could be done with the available software. The time from February to July was spent testing various system components.

Several system limitations that became evident as a result of this testing were satisfactorily resolved. These included:

- Inadequate retransmission range
- Limited retransmitter battery power capacity
- Poor navaid phase lock and track capability
- Program load and data entry inefficiencies
- Poor software reliability
- Phase/time difference measurement inaccuracies
- Inconsistencies in certain algorithms.

An explanation of these deficiencies and the steps taken to correct them is detailed in the report listed in paragraph 4.10. Limitations in the original system display that were not evident until the system was operated indicated that a reassesment of display requirements would be desirable. This reassesment was performed by a contractor and documented in a report listed in paragraph 4.1. The contractor was ultimately selected to provide additional display capabilities for the system.

Detailed system testing began in July 1973, but was terminated in mid-August when the OMEGA station in Norway ceased transmitting. This, coupled with the inability of the system software to select the appropriate Loran-C cycle for position determination, forced cessation of testing. No OMEGA simulator capable of supplying suitable (3-frequency format) signals was available. Therefore, the design and construction of one was begun as in-house effort. During this period of testing, the feasibility of transmitting DALS signals in the same channel as voice communications was conducted. The results were reported and are summarized in paragraph 4.3. The report concluded that the DALS signals and voice communications could co-exist on the same frequency although there would be some unresolvable interference. This information provided the basis for development of a beacon that transmits the distress tone and identification code, as well as a decoder/display unit, during the summer of 1974. Additionally, Operations Research Inc. (ORI), was awarded a contract for studies concerning the implementation of the DALS as an operational system. The results of these studies were published in the report listed in paragraph 4.4.

After the OMEGA station in Norway begain transmitting again in

January 1974, operational testing resumed and continued through May of that year. During this period, additional software development was accomplised and the prototype system was made ready for full system testing.

The period between May and December 1974 was used for testing of the prototype system. Included was a demonstration wherein the yachts involved in the preliminaries to the America's Cup Races were tracked from their docks to the race area and return via DALS. The result of this testing was documented in several letter reports and is summarized in the report listed in paragraph 4.10.

Plans now called for a pre-operational DALS with the telemetry frequency shifted to the VHF marine band. Initial system testing had used telemetry frequencies in a UHF experimental band. Therefore, investigations began into the problems associated with reformation of wide band analog signals for transmission on narrow band frequencies and resulted in the study of the compression of Loran-C signals for retransmission in the DALS. The study resulted in a report listed in paragraph 4.9. The conclusion of this work was that a risky development program would be necessary to produce equipment suitable for narrow band Loran-C retransmission for DALS. This coupled with adequate accuracy obtainable using OMEGA signals caused the scope of the project to be modified. The pre-operational or second generation system would utilize only OMEGA signals.

The period between January and June 1975 was dedicated to a study of previous activity and development of the specifications for the pre-operational DALS. The intent was to test a pre-operational system at a Coast Guard SAR unit. Contracts were let for the following items:

- A pre-operational DALS Display Sub-System

- LO-CATE® III hardware modified for the pre-operational DALS

- VHF-FM telemetry equipment capable of retransmitting narrow band OMEGA navaid signals

- Study of the Loran-C/OMEGA geometry in the U.S. Coastal Confluence Zone (CCZ)

Budgetary limitations and a management decision caused the termination of the project prior to full development of the pre-operational DALS.

With the intent of organizing and documenting all the DALS information for future use, two additional contracts were let; one each for

hardware and software documentation. This information is compiled in ten volumes, two sets of which are stored at R&DC.

3. DALS CAPABILITIES

3.1 Signal Flow in the DALS

The overall signal flow in the DALS is shown in Figure 2. The information which is processed by the DALS is obtained from the Loran-C and OMEGA navigation systems and the Automatic Identification (AIDS) code preprogrammed in the retransmitter. The function of the DALS is to obtain the position of the retransmitter relative to the base station and the identification of the retransmitter as described by the AIDS code. This output may be obtained in several forms, depending on the operating mode of the system. If signals from both the Loran-C and OMEGA navigation systems are used simultaneously, the position output is described graphically on the plotter using a preprinted map. In this configuration, position is indicated by the plotter drawing a retransmitter ID number at the appropriate location on the map. Identification data are presented visually on the readout which is an integral part of the AIDS decoder/display unit. In the OMEGA only mode of operation, the position information is presented on a plasma display. The first operational software used the plotter as the display device for all three modes. When software was developed for the plasma display, software timing constraints would not allow Loran-C or LOL determined positions to be displayed on the plasma display unit. Again, the identification is obtained visually on the AIDS decoder/display readout.

Retransmitter signals received at the base station may be obtained either directly from the retransmitter or relayed through a telemetry translator. The purpose of the translator is to enable signals to be received when a line of sight condition does not exist between the retransmitter and the base station. In such cases, the telemetry translator would be deployed on a high tower or mounted in an aircraft. The output of the telemetry sub-system contains both unprocessed Loran-C and OMEGA navigation signals and PSK encoded identification data (AIDS code).

The identification data from the telemetry sub-system is directed to the AIDS decoder/display. The AIDS detects the presence of a distress message, demodulates the PSK modulated identification information and presents the identification message on an alpha-numeric display. These identification data are also provided to the computer to initiate positioning and tracking of the remote object. The demodulation and display of the identification information is independent of the DALS computer.

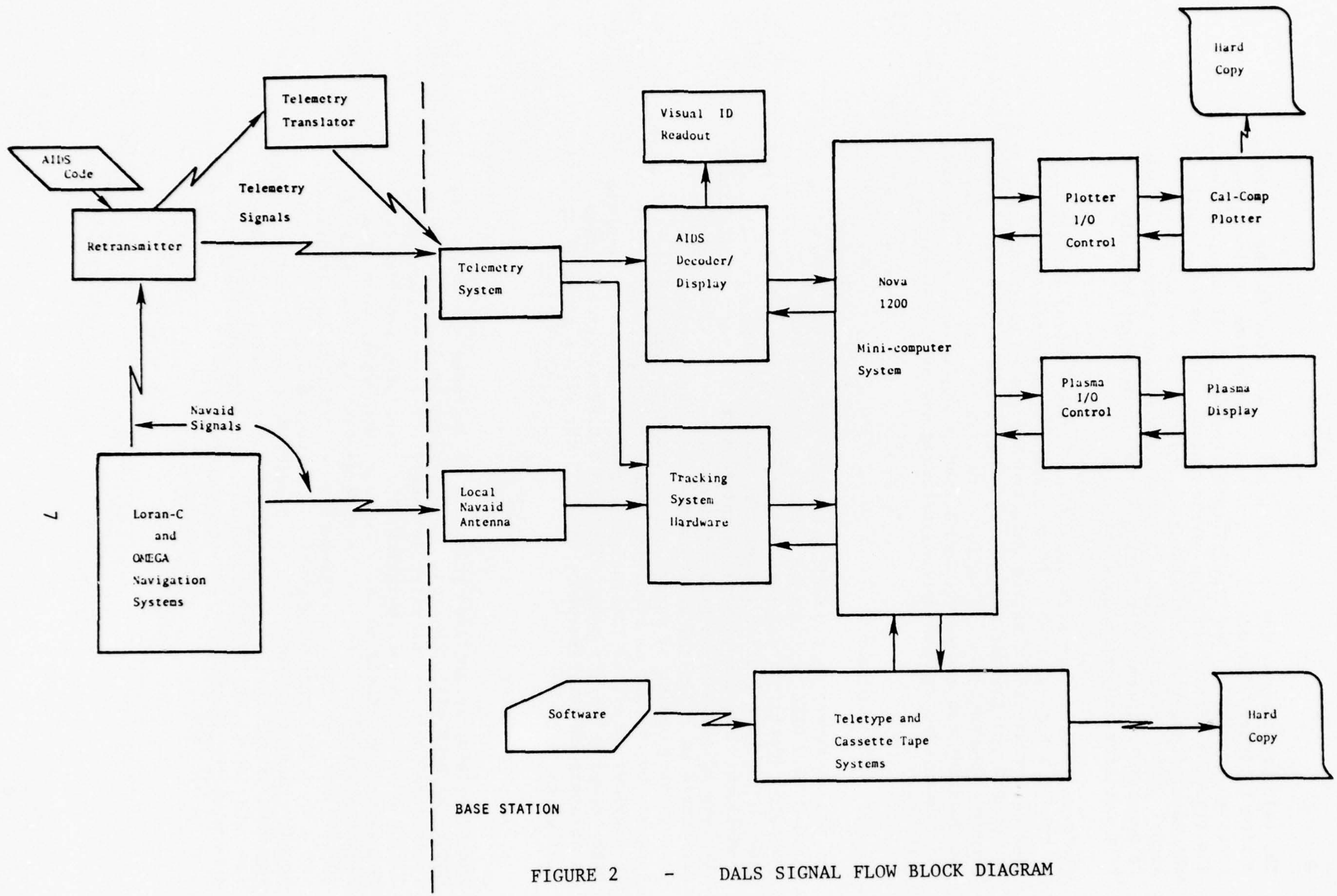


FIGURE 2 - DALS SIGNAL FLOW BLOCK DIAGRAM

The telemetry sub-system navaid output is directed to the tracking system hardware. In addition, the tracking system obtains signals received locally at the base station from the local navaid antenna. The tracking system hardware preconditions the navaid signals through filtering and amplification and makes measurements of signal phase under computer control, enabling the computer software to generate information relating to the position of both the retransmitter and the base station.

The Nova 1200 minicomputer sub-system is the central element of the DALS base station. In accordance with system software entered through the cassette data storage system and/or the teletype, the computer organizes and converts the raw input data into graphic output presentations of position. Through the use of the teletype, the operator can change the operational software to a new library and command the various options afforded him by the operating software.

3.2 Retransmitter

The retransmitter is a portable hand-held device which receives Loran-C and OMEGA navigation signals, augments them with locally-generated identification data and retransmits the composite signal back to the base station either directly or through the DALS translator. The identification information for each retransmitter consists of seven alpha-numeric characters. These characters are stored as a digital data message in a read-only memory. Through programming of memory chips, the retransmitter identification code may be changed as required. Power for the retransmitter is provided by either internal batteries or through an external high-capacity battery pack. The DALS retransmitter transmits on an assigned test frequency of 347.2 MHz with a power of approximately 0.75 watts.

3.3 Translator

The translator is provided primarily to increase the range over which the DALS will function. In a typical application, the translator would be installed in a helicopter or rescue craft. In its primary mode of operation, the translator receives the retransmitter signals on 347.2 MHz and retransmits them at a higher power of 12 watts to the base station on a frequency of 407.975 MHz. To increase the system versatility, the translator has a secondary mode of operation. In this mode, the function of the translator mimics that of a retransmitter, providing locally received navaid data and identification data directly to the base station at 407.975 MHz, which enables the base station to determine the location of the translator.

3.4 Telemetry System

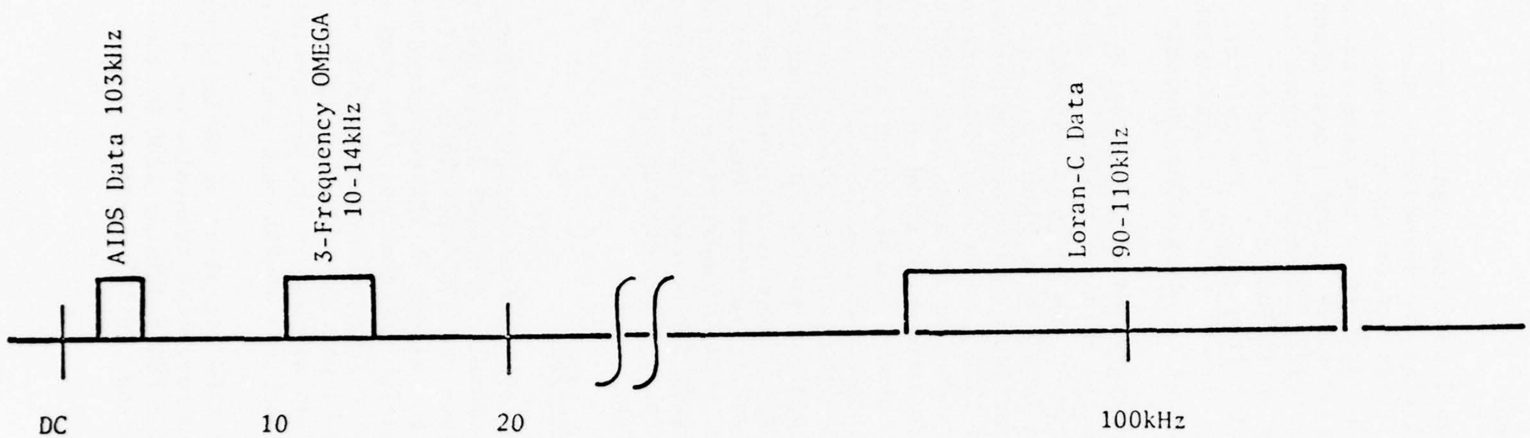
The telemetry sub-system intercepts signals from either the retransmitter or the translator, amplifies and demodulates them to provide baseband output suitable for processing by other system components. The telemetry sub-system consists of two base station telemetry antennas, associated preamplifiers, and a dual channel telemetry receiver. One of the receiver channels is tuned to the 347.2 MHz retransmitter frequency while the second channel is tuned to the 407.975 MHz translator frequency. The telemetry sub-system is capable of receiving either frequency upon operator selection. Both frequencies may not be received simultaneously.

All transmitter and receiver frequencies in the DALS are crystal controlled, eliminating the need for tuning the telemetry system components. The spectrum of the baseband information processed by the telemetry system is shown in Figure 3. The AIDS information occupies the baseband portion of the spectrum between approximately 1 kHz and 3 kHz. Above this band are the three frequencies of the OMEGA navigation system and the associated OMEGA spectrum noise. The OMEGA signals are transmitted in their received bandwidth at 10 kHz-14 kHz. The Loran-C signals occupy the frequency band from approximately 90 kHz-110 kHz; again being retransmitted at the frequency at which they are received. The telemetry channel bandwidth is twice the highest modulating frequency or for the DALS, 220 kHz. In practice, several sidebands are transmitted and for the DALS, a telemetry receiver bandwidth of approximately 1 mHz has been provided. These bandwidths are dictated by the desire to simply retransmit the navaid signals without extensive processing. This approach was selected as it would provide the lowest cost retransmitter.

3.5 AIDS Decoder/Display

The AIDS decoder/display sub-system accepts baseband signals from the telemetry sub-system. The AIDS signal has been designed to mimic the standard two-tone 1300 Hz/2200 Hz distress signal. The 2200 Hz portion of the signal is PSK modulated with the retransmitter or translator identification information. The AIDS decoder/display decodes the identification information, providing outputs to the computer. The 1300 Hz portion of the signal is used to identify the presence of a distress signal. In the present DALS, the 1300 Hz tone is used solely to enable a loudspeaker squelch system.

The construction of the AIDS signal is shown in Figure 4a. The AIDS signal alternates between the transmission of a pure 1300 Hz tone for 290.9 msec and a PSK modulated 2200 Hz tone for 407.2 msec. The data transmitted during the 407.2 msec PSK message are shown in Figure 4b.



Telemetry Frequencies:

Retransmitter	347.2MHz	0.75 Watts
Translator	407.975MHz	12 Watts

FIGURE 3 - TELEMETRY SPECTRUM

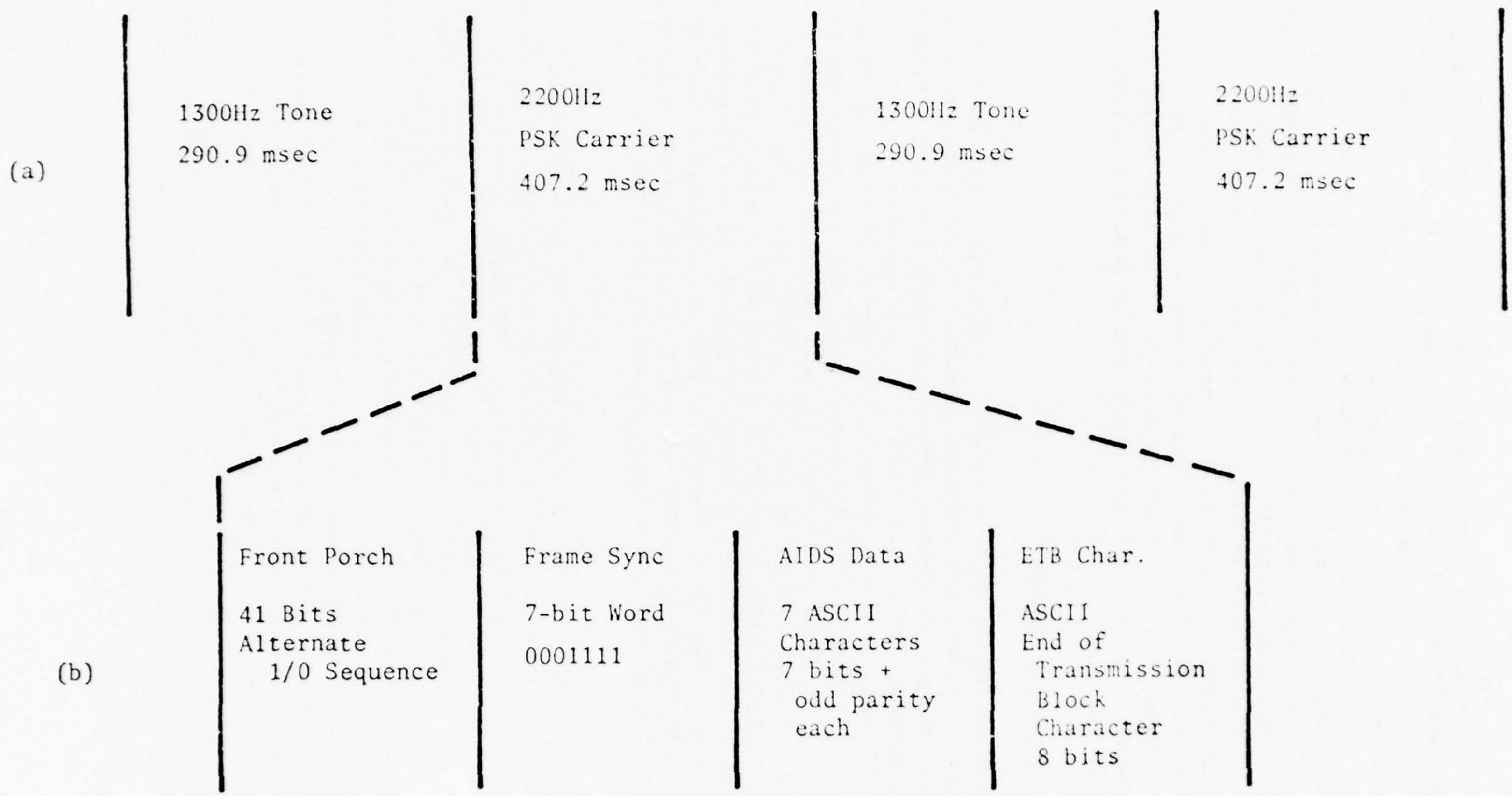


FIGURE 4 - AIDS SIGNAL FORMAT

The initial portion of the message consists of a "front porch" and frame synchronization word. The function of this portion of the message is to bring the AIDS decoder/display demodulator into synchronism with the retransmitter or translator data modulator. Following the frame synchronization word is the encoded identification data. The AIDS transmits the identification data using ASCII coding. The storage space in the retransmitter ROM permits selection of up to seven alpha-numeric characters or special symbols. The end of the message is signified by the transmission of an End of Transmission Block (ETB) character. The decoder/display simultaneously displays two identification messages, the most current message and the previous message. The AIDS output to the computer is used to initiate the remote position determing portion of the DALS.

3.6 Tracking System

The DALS tracking concept is based on the maximum utilization of a software controlled computer system. The computer measures navigation signal parameters through an interface with a generalized time measurement device referred to as the comparator card. A block diagram of this portion of the system is shown in Figure 5. The comparator card's main function is to take two measurements of the state of the input navaid signals at times prescribed by a computer word stored on the comparator card. The output of the comparator card is an error signal which relays back to the computer the status of the navaid signals at the requested sampling time. The error signals enable the computer software to constantly modify the times at which the signals are sampled, implementing a phase-locked loop, locked to the input navaid signal.

The inputs to the comparator cards are hard-limited versions of the navaid signal available from both the telemetry sub-system and the local navaid antenna coupler. The input signals are converted into hard-limited signals through the use of RF heads comprised of bandpass filters and hard-limited amplifiers. The bandpass filters select the navaid frequency to be amplified, rejecting out-of-band noise and unwanted signals. Hard-limiting removes amplitude variations in the signals retaining only the relative time at which signal zero crossings occur. The output of the RF head is a hard-limited signal which switches between a low and high TTL logic state, dependent upon whether the filtered input navaid signal is of negative or positive polarity with respect to the average (long-term DC) voltage level of the input. The computer extracts information from the hard-limited signals by causing the comparator card to sense the logic state of the

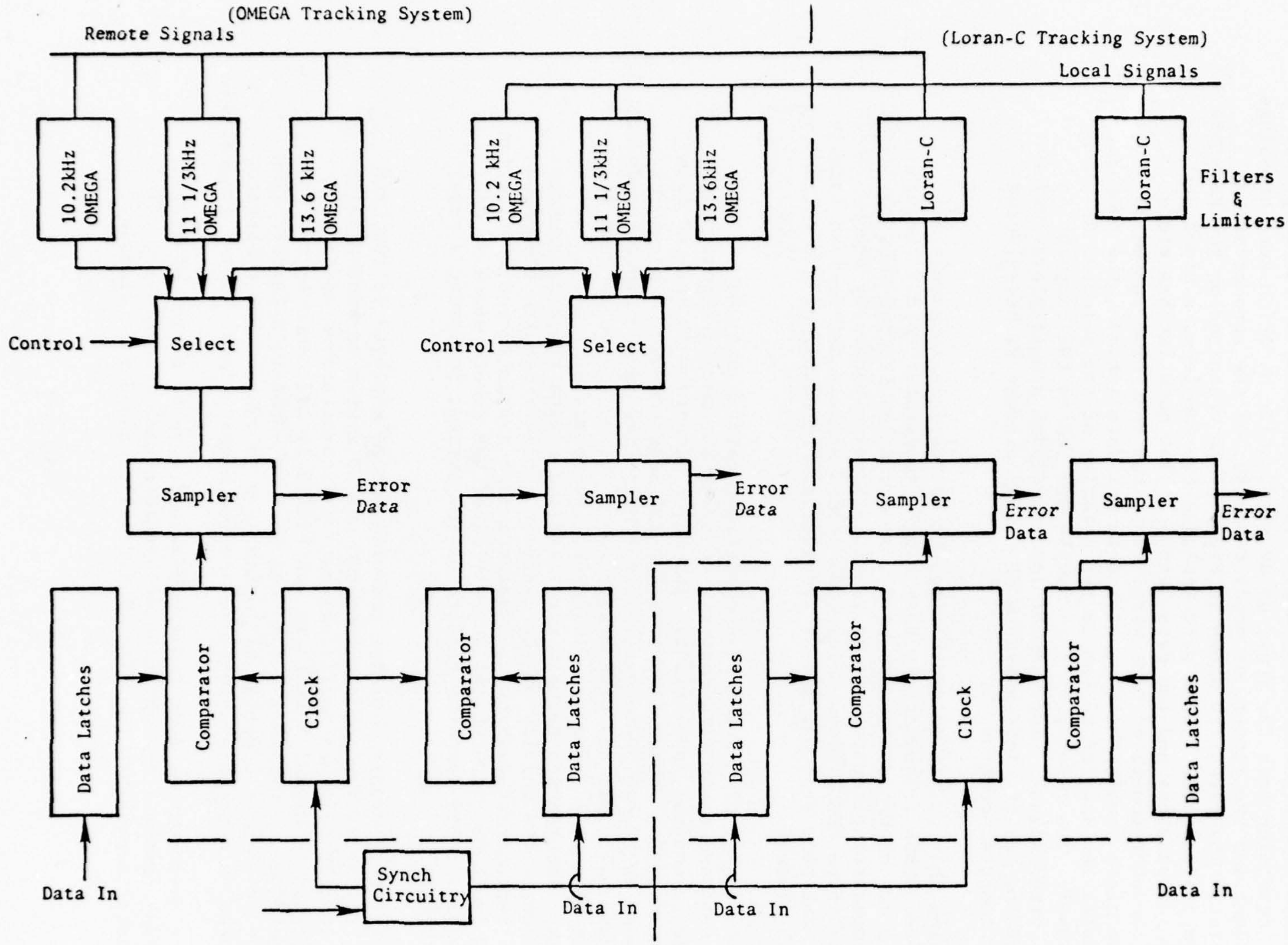


FIGURE 5 - RF HEADS AND COMPARATOR CARDS, BLOCK DIAGRAM

signal at a predetermined sample time. This enables the computer to determine both the mean, or average, point at which zero crossings occur; and the jitter, or predictability, of the zero crossing point. The circuitry shown in Figure 5 is contained on two separate comparator cards. Each card includes two samplers, a clock, two comparators and two data latches. The data latches store a computer-generated time word. When the real time stored in the clock equals the time stored in the data latches, the comparator causes the sampler to sample the polarity of the selected RF signal. The results of this sample are fed to the computer as an error signal. The sampler input includes a multiplexer which enables one of eight possible RF signal sources to be selected by computer command.

Using this multiplex capability, it is possible to sample all three OMEGA frequencies with a single comparator card. Through the use of two comparator cards, or equivalently four sets of comparator circuitry, it is possible to simultaneously track the three OMEGA frequencies and Loran-C signals as received locally at the base station, and as provided at the output of the telemetry sub-system.

The concept of using a time comparator card in conjunction with a software controlled computer to track the navaid signals has led to several innovations. The major advantage is derived from the use of a common time base for all measurements. The clocks shown in Figure 5 are externally synchronized upon computer command. Thus, all phase and time measurements are made with respect to the same time reference. The ability to transfer phase and time measurements between the local and remote tracking systems enhances the ability of the system to quickly acquire the phase of retransmitted signals, enables a more sophisticated application of local or differential correction of the remote signals, and enables rapid computer restart of the system, following a power failure.

A further advantage of the tracking scheme employed in the DALS is its ability to change from one navaid system to another with primarily software modifications. All computations and logic related to signal format are controlled by the computer software. Therefore, converting the system from an OMEGA to a Loran-C time format is only a matter of loading new software. The comparator cards do not contain logic related to navaid signal format generation.

The basic output from the tracking software is a time of arrival (TOA) number for each selected navaid signal transmission. This number represents the time of arrival of the navaid signals.

By differencing the TOA numbers, the familiar time difference or phase difference values normally used in Loran-C and OMEGA navigation are obtained. In addition to the TOA value, a signal quality number is generated to determine the usefulness of each signal.

3.7 Data Processing

Before the navaid time of arrival data can be used, they must be converted into an output with a geographical reference. This part of the data processing occurs during those periods of time when the computer is not tending to the updating and processing of the comparator cards and other "real time" data. The conversion to a geographical reference is accomplished through the use of a computer program. Given the time of arrival information, an approximate location for the base station and retransmitter and the location of the navaid transmitters, this program outputs both latitude and longitude of the remote retransmitter to the teletype and an X-Y displacement signal to an X-Y plotter or plasma display.

The DALS software permits two different modes of operation. The first employs signals from both the Loran-C and a single frequency of the OMEGA navigation system and is referred to as the Loran-C/OMEGA/Loran-C mode. The second employs all three frequencies of the OMEGA navigation system and is referred to as the three-frequency OMEGA mode.

3.7.1 Loran-C/OMEGA/Loran-C

In a typical Loran-C receiver, the shape of the Loran-C pulse is used to identify the third cycle. In a retransmission positioning system such as the DALS, the amplitude character of the Loran-C pulse is distorted in the process of retransmission. This distortion makes it difficult, if not impossible, to identify the third cycle of the Loran-C pulse without additional information.

In the DALS Loran-C/OMEGA/Loran-C mode, this additional information is provided through the use of OMEGA navigation signals.

The use of both Loran-C and OMEGA to solve the Loran-C cycle identification problem is based on the following logic:

- Through the use of the signal detection procedures, it is possible to lockup and track a Loran-C pulse cycle which is located somewhere on the leading edge of the pulse: for example, the third cycle ± 2 cycles. While this fails to provide an absolute position, it does provide a position in the general region of the true target location.

- The World-Wide OMEGA system is a CW hyperbolic radio-navigation aid. This system, when operated in a differential mode, can provide position to an accuracy of better than 500 meters, depending upon the user's distance from the differential monitor. However, the position is ambiguous because it is impossible to identify which cycle of the CW pulse is being tracked. For this reason, the OMEGA system has position ambiguities which occur at intervals of 1 carrier cycle.

The Loran-C and the OMEGA navigation systems are used in a mutually aiding configuration as follows: An initial lock is obtained using the Loran-C signals. While this is not an absolute position, it is close enough to identify the correct OMEGA lane. Having obtained the correct OMEGA lane from the Loran-C lock, the OMEGA lane count and differential phase information are used to determine the position of the remote object to within the obtainable differential OMEGA positioning accuracy. This corrected OMEGA position is unambiguous and accurate enough to identify the correct Loran-C cycle. Using the corrected OMEGA position, the tracking point on the Loran-C pulse is jumped to the correct cycle (actually, in the LO-CATE® III/DALS system to correct the TDs). After this correction, the time differences provided by the Loran-C tracking system are accurate within the capability of the Loran-C system, some 30-100 meters, depending on location and geomtry.

The procedure then is:

- Obtain a crude position using Loran-C
- Use crude Loran-C position to obtain an unambiguous OMEGA position
- Correct the point of Loran-C lock to obtain a high-accuracy Loran-C position.

The conditions under which this technique will provide correct third cycle identifications depend on both Loran-C and OMEGA system geometries as well as signal strength.

3.7.2 Three-Frequency OMEGA

The three-frequency OMEGA software uses measurements obtained by tracking the three frequencies of the OMEGA navigation system (10.2 kHz, 11 1/3 kHz, 13.6 kHz). The use of three frequencies permits an unambiguous fix to be obtained with a larger initial retransmitter location uncertainty.

Whenever a remote transmitter is acquired, the three-frequency OMEGA goedetic process synchronizes the 1 2/15 kHz and 3.4 kHz lanes by differencing the 11 1/3 kHz and 10.2 kHz frequencies and the 13.6 kHz and 10.2 kHz frequencies. The application of three-frequency OMEGA in the DALS differs from the typical navigation problem in that differential corrections may be applied to the remote signal. By tracking the locally received OMEGA signals, the base station can monitor variations in received OMEGA phase caused by propagation anomalies. By monitoring these variations, the system generates a correction which is applied prior to the computation of geographic position.

3.8 Supervisory Software and Support Peripherals

In addition to algorithms which provide for the tracking of the navaid signals and the conversion of these outputs into displayed information, the DALS computer also includes supervisory software. Essentially, this software ties the various system functions together, determining the sequence in which the various functions occur and the priority with which interrupts from peripheral devices are handled.

The remaining computer peripherals are concerned with the input and display of information. The primary operator interaction with the DALS is through a teletype. Software or program storage for both the computer programs and the plasma display maps are contained on magnetic tape in a cassette data storage system.

3.9 Display Systems

Two graphical output display devices have been used in the DALS. These are:

- A Calcomp Model 502, 34"x31" flatbed plotter

- A plasma display provided by Mystech Associates, Inc.

In the current system configuration, the Calcomp plotter is used with the Loran-C/OMEGA/Loran-C software and the plasma display is used with the three-frequency OMEGA software.

The Calcomp Model 502 plotter provides graphical output on a pre-printed chart. The operating mode of the plotter software changes according to the received AIDS code. If a retransmitter with a prefix DIS is received (DIS-n1,n2,n3) the AIDS code has been transmitted by a retransmitter assumed to represent a distress

situation. In this case, the software will position the Calcomp plotter at the relative map location of the retransmitted signal and write the character n3. Following the drawing of this single symbol, the software waits for the next AIDS code to be received. If a new code is received, the plotter will move to the associated position and print the new symbol. If the same signal is reprocessed, the plotter output is supressed until the location of the retransmitter has moved at least 1/4" away from the previously plotted position, as represented on the chart. This characteristic prevents continuous marking of a stationary target. The receipt of an AIDS code with an RES prefix indicates that the system is tracking a rescue vehicle. In this mode, a continuous track of retransmitter position is drawn. This track is continued until either a new AIDS code is received or the operator manually aborts the track.

The plasma display provides a much more sophisticated system output. This output includes not only the identification of multiple targets, but also provides for the software generation of a background chart. The display can provide the following system functions:

- Upon system initialization, input from a tape cassette storage device, one of several pre-stored navigation charts, and present this chart on the flat-plate display

- Under operator control vary the full scale of the display to any one of 2, 4, 6, 8, 16, 32 and 64 miles.

- Under operator control, center the display on any desired point.

- Display, in the proper geographic location with appropriate symbology, up to eight (8) fixed points, manually entered by the operator from the console

- Display, with a distinctive symbol, the geographic position of the DALS base station.

- For tracks derived from the DALS system, display upon operator request, track position history data

- Upon operator request, drop fixed points and/or moving tracks

- By means of an operator-controlled cursor, read out the latitude/longitude of any display point or read out the range and bearing of any display point from any other display point

- Provide for operator initialization (reset to original scale and center) of the display upon request.

The DALS plasma Display sub-system operates under control of the system computer program running in the DALS computer. The operating program is provided in two forms:

- The basic program is the "DALS Display Sub-System Operational Program" provided by Mystech Associates, Inc. in magnetic tape cassette format. This program provides "stand alone" operation of the display sub-system independent of other components of DALS. This is used primarily for evaluation, demonstration and operator training.

- A functionally identical program is intergrated into the DALS operational program provided by Beukers Laboratories, Inc. This integrates the display operation with the remainder of DALS and is used in normal system operation.

4.0 DALS RELATED REPORTS

The following are abstracts or excerpts from all the major DALS-related reports.

4.1 Preliminary Design of a Search and Rescue Command and Control System for use with the Distress Alerting and Locating System; prepared by Mystech Associates, Inc. as Document No. D-35-73 dtd 28 June 1973

EXCERPT FROM REPORT

This document sets forth the concept of, and a preliminary design for, a display control, and processing system which, when fully integrated with the U.S. Coast Guard Distress Alerting and Locating System (DALS), will result in a complete coastal Search and Rescue Command and Control System.

Two such systems are described. These are functionally identical but differ somewhat in the type of display system utilized. The first of these employs a large-screen projection-type display similar to that used in the Coast Guard OASIS, and is intended for a permanent installation at a major Rescue Coordination Center (RCC). The second employs flat-plate plasma type displays similar to those used in the U.S. Navy MATCH-NAV System and is intended for use in a smaller installation or for portable or semi-mobile use.

Included here are the functional requirements for the SAR Command and Control system, a discussion of the application and operation of the system, and for each of the two systems described, a list of required hardware is given, the system software requirements are discussed, and the integration with the DALS is described. For each, estimates of the cost of system implementation is included.

4.2 LO-CATE® III/DALS Tracking and Positioning Algorithms Loran-C and Loran-C/OMEGA/Loran-C Modes and including OMEGA Signal Measurement Algorithms as Appendix A; prepared by Cambridge Engineering as Final Report CE-4005 dtd 15 July 1974

ABSTRACT

This report describes tracking and positioning algorithms employed in the LO-CATE® III/DALS system. It contains descriptions of the equations and the logic used to acquire and track Loran-C and OMEGA signals, and the geodetic routines used to derive position from Loran-C and from a combination of Loran-C and OMEGA signals.

The tracking and positioning algorithms presented in this report document the current LO-CATE® III/DALS system routines. This report does not attempt to analyze the ability of these algorithms to meet the overall DALS system specification.

4.3 Test of Compatability of the LO-CATE® III Distress Alerting and Locating System (DALS) in Co-Channel Operation with an FM Voice Communications System; prepared by Coast Guard Research and Development Center as Report No. CG-D-24-75 (ADA 002827) dtd July 1974

ABSTRACT

A test of co-channel FM compatability of the LO-CATE® III/DALS and a voice communication system was conducted to determine what effects each system has on the other when operated simultaneously on a common FM channel. The test was conducted in two phases. Phase I of the test determined the effect on voice communications intelligibility as a function of DALS interference. Phase II determined the effect on DALS operation as function of voice communications. The test showed that the two systems can be operated in a co-channel configuration; however, some degradation of each system's performance can be expected.

The results showed that the expected degradation of both voice intelligibility and DALS operation can be predicted quite accurately as a function of transmitter carrier power and distance from the common receiver site.

Specifically, due to the nature of FM systems, there is a $\pm$6db range of receiver carrier power over which the discriminator is affected by multiple signals. If one signal is received at the receiver site with $\pm$6db or more relative carrier power, it captures the FM discriminator entirely, and the other signal has no effect. Within the $\pm$6db range, voice intelligibility is 90% or greater for voice/DALS carrier power ratio $\pm$1db; DALS distress alerting and identification tones are decoded accurately 90% or more for DALS/voice carrier power ratios $\pm$3db.

A prediction nomogram is presented which indicates expected co-channel interference as a function of transmitter power and distance from any common receiver site.

4.4 Engineering Studies in Support of the Implementation Plan for the Distress Alerting and Locating System (DALS); prepared by Operations Research, Inc., as Report No. TR870 dtd 30 October 1974

ABSTRACT

This report documents the analysis of several engineering questions associated with the implementation of a Distress Alerting and Locating System (DALS). These engineering questions fall under two major catagories.

First is the utilization of the existing USCG VHF-FM National Distress System facilities as components of the DALS. The second is the implementation of DALS under varying capabilities. Under the first catagory the following specific questions were addressed:

- If the existing USCG VHF-FM National Distress System receiving sites were used for DALS, what coverage zones would be achieved?

- With these coverage zones, can three-frequency OMEGA ambiguity resolution be achieved? If not, what techniques are available to resolve the ambiguity?

- What interference effects will be experienced if a DALS transmission and a VHF-FM voice transmission are coincident in time in the same VHF-FM channel assignment (i.e., Channel 16)?

- What technical problems will be encountered in attempting to use the communications facilities associated with the existing National Distress System?

Under the second catagory, the following specific question was addressed.

- What are the costs and benefits associated with DALS systems with varying capabilities?

Results were obtained in all the above questions and are contained in this report.

4.5 Demonstration and Test of DALS VHF-FM Distress Alerting and Identification System; CO R&DC letter report 751140 dtd 31 Dec 1974

EXCERPT FROM REPORT

The demonstration tests showed that the system operates as expected and has excellent potential as a search and rescue tool. The demonstrations showed the effectiveness of the system's two most important functions (Distress Alerting and Signal Beacon for Homing) and the possible uses for its other function (identification, situation, location notification).

4.6 A Simulation of Loran-C/OMEGA Geometry in the U.S. Coastal Confluence; prepared by Cambridge Engineering as Report CE-4009 dtd 31 Jan 1975

ABSTRACT

The USCG LO-CATE® III/DALS system has the capability to simultaneously track signals from both the Loran-C and OMEGA navigation systems and to use OMEGA position information to resolve Loran-C cycle ambiguities. Use of the Loran-C/OMEGA/Loran-C lockup technique requires that an initially incorrect Loran-C lock (caused by improper cycle identifcation) be capable of specifying the correct OMEGA lane count and further, that the accuracy of the OMEGA position fix be capable of unambiguously selecting the correct Loran-C time differences. This report analyzes the Loran-C and OMEGA geometry present in the Coastal Confluence of the United States to determine the ability of the system geometries to support the Loran-C/OMEGA/Loran-C lockup technique.

4.7 Test and Evaluation of Distress Alerting and Locating System (DALS) Capabilities for Helicopter/Icebreaker Operations; CO R&DC letter report 751140B.02 dtd 31 Mar 1975

EXCERPT FROM REPORT

The majority of data taken to develop this report were from the test and evaluation of LO-CATE® III for SAR, VTS and buoy positioning; reported seperately. Additional testing to satisfy the specific helicopter requirements of this plan was conducted using a helicopter at the R&D Center in November and December 1974. All location data presented are based on the three-frequency OMEGA (3FO) mode of operation while tracking data is presented using the Loran-C mode only.

4.8 Test and Evaluation of Distress Alerting and Locating System (DALS) for SAR, VTS, and Buoy Position Monitoring; CO R&DC letter report 751140B.01 dtd 31 Mar 1975

ABSTRACT

The basic reference for this report is the "Detailed Test Plan for a Distress Alerting and Locating System (DALS)" prepared by NATC Patuxent River, MD under contract DOT-CG-23,517A.

The data presented were gathered between May and December 1974. They contain the detailed results of the LO-CATE® III test and evaluation in the three-frequency OMEGA (3FO) mode for location and the Loran-C mode for vessel tracking and buoy position monitoring.

All efforts to develop location capabilities to better that 50% reliabilitiy for the Loran-C only or Loran-C/OMEGA/Loran-C modes of operation were set aside in April 1974. It became obvious that successful location using one of the Loran-C modes would require an additional six months to one year effort before detailed testing could be started.

A technique for using the Loran-C mode for vessel tracking was developed. It proved highly effective for simultaneous tracking of two vessels during the America's Cup Races in July, August and September of 1974. Limited buoy position data were extracted during this period and are also presented.

4.9 Loran-C Retransmission Bandwidth Reduction Study; prepared by Cambridge Engineering as Report CE-4010 dtd 30 April 1975

EXCERPT FROM REPORT

This report presents the results of a study of Loran-C retransmission bandwidth reduction techniques in support of the Coast Guard

DALS program. The requirement for bandwidth reduction is imposed by the bandwidth allocations of authorized communications channels and the general need to conserve bandwidth. This study considered both the limitations of the narrow band VHF-FM channels assigned to the boating community and a line-of-site link with the available bandwidth adjusted to meet the minimum requirements of a specific retransmission technique.

4.10 Development of a Distress Alerting and Locating System (DALS); prepared by Coast Guard Research and Development Center as Report No. CG-D-186-75 (ADA023841) dtd November 1975

ABSTRACT

An automated method of determining a distressed vessel's situation and position could be useful in the U.S. Coast Guard's search and rescue mission. Evaluation of commercially available retransmitting equipment, modified for use as a Distress Alerting and Locating System (DALS), was undertaken to determine its capabilities for automatically locating and identifying a vessel in distress, usefulness as a buoy position monitoring system, and usefulness as a vessel tracking system.

The system employs a hand-held radio-navigational signal retransmitting device which, when energized by a recreational boater in time of distress, transmits a distress alerting and identifying signal along with local area navigational aid information to a DALS base station. Provision exists for extension of the operating range of the system through use of telemetry equipment deployed in a vessel, aircraft or additional shore station.

The system can utilize either OMEGA or Loran-C navigational signals, or a combination of inputs from both navigational aids. Use of the OMEGA navigational system idicated positional accuracies of 400 to 700 yard within the 10-mile operating range with a maximum access/locate time of 3 minutes. Loran-C was unusable for position location due to system hardware/software limitations and navaid system geographics, although vessel tracking and station keeping monitoring accuracies in the order of 25 yards were obtained.

A detailed test plan and discussion of the results of the test and evaulation are included as appendicies.

4.11 Report on the Technique and Hardware Development of a Method of Narrow Banding the OMEGA Navigational System Signals for Retransmission in the Distress Alerting and Locating System; CO R&DC letter report 761140 dtd 26 May 1976.

EXCERPT FROM REPORT

The signal bandwidth conversion equipment was developed as two separate groups of hardware with each group performing identical functions but using different techniques. One technique uses a method of frequency division multiplexing while the other does a frequency translation using phase-locked loops.

As delivered each method of signal conversion satisfied the minimum requirements. The narrow banding hardware does not appreciably increase the cost, size, complexity or weight of the retransmitter. The power drain is low compared to the transmitter requirements and as such does not require additional power source capabilities. As expected, some degradation of system accuracy occurred; on the order of 400 to 600 yards over and above the reported system accuracy of 600 yards.

5. ADDITIONAL CAPABILITIES

5.1 AIDS Decoder/Display

The AIDS (automatic identification) capability was added to the LO-CATE III system at the request of the U.S. Coast Guard. The original AIDS was conceived by SECODE division of Communications Industries, Inc.; Dallas, Texas. Prior to inclusion in the DALS, the AIDS concept underwent additional development by Beukers Laboratories. However, the original idea of a generalized data transmission capability was still retained. In the present DALS, the AIDS encoder and decoders stand independent of the balance of the system. This enables these components to be used on other applications where generalized data transmission is desired. The use of the PSK data modulation technique permits the data rate and carrier frequency to be varied over a wide range of frequency and band rates with only minor system changes related to oscillator frequencies and filter bandwidths. In its existing configuration, the AIDS could be used as the data link portion of a retransmission system which employs digital data obtained from sophisticated navigation receivers. For example, the time difference outputs from a Loran-C receiver could be transmitted over voice grade links using the AIDS. The present AIDS decoder/display can display up to 15 characters. Messages of greater length may be transmitted provided they are terminated with the proper end-of-transmission block (ETB) character.

By adjusting oscillator frequencies in both the encoder and decoder, it is possible to use the AIDS concept at much lower carrier frequencies and bit rates. In particular, it is possible to

transmit data at a very slow rate using sub-audible tones on VHF communication gear. In these applications however, care must be taken to be sure that the transmission link has a well-behaved phase characteristic in the passband of the PSK data stream. This may limit the use to communcation links where the data stream could be injected following voice-shaping filters.

5.2 Tracking System

5.2.1 Linear Phase Measurement

There are several areas in which the current DALS tracking system could be improved and/or adapted to changes in signal format. The use of polarity detection in the DALS tracker has several disadvantages which could be overcome through the use of the linear phase measurement mode. The main disadvantages are:

- The inability to effectively track Loran-C pulses which have certain forms of communication modulation imposed on the front edge of the pulse

- The use of linear detection would decrease the settling time required during signal acquisition.

Several systems of modulation have been used in conjunction with Loran-C transmissions. All of these systems have phase shifted the pulses in a symmetrical manner around the zero phase point. In a polarity detection receiver, this phase modulation tends to decrease the gain of the receiver and introduce a dead zone in which precise tracking is not possible. The use of linear detection enables communication phase shifts to be balanced out, permitting signal tracking with only minor adjustments in tracking gain.

A polarity detector measures only the polarity of the phase tracking error in the receiver, and is not sensitive to the magnitude of the error. Once the receiver is phase locked, the noise jitter of the selected tracking edge serves to linearize the response of the polarity detector. During signal acquisition, however, large phase errors will cause the output of the polarity detector to stay at either the positive or negative limit because the system gain must be adjusted to provide adequate performance for the smallest phase angle at which saturation will occur, the response to the larger errors is necessarily reduced. The use of linear detection permits the gain of the phase locked loop to increase for larger phase errors, permitting faster overall settling times.

An additional advantage of linear detection is that it is valuable in tracking other forms of signal modulation. For example, the U.S. Navy VLF communication network has been successfully used for tracking and positioning application. Currently it is possible to track these stations using polarity detection. However, a pending change to the signal format from FSK to MSK modulation will make it necessary to make a linear measurment of phase in order to obtain tracking information from the signals.

Beyond the use of linear detection to simply improve on the performance of the phase locked loop incremented in the current DALS, linear detection may be used to implement non-closed loop tracking algorithms. These algorithms make a series of phase measurements on the incoming signal without adjusting the point of measurement in accordance with the measured error. The series of phase measurements so derived are then fit to a regression curve of phase vs time with the final output being the value of phase at a particular time as determined from the regression curve.

5.2.2 Loran-C Third Cycle Identification

The present DALS employs the known position of the base station to establish the initial Loran-C time differences and OMEGA lane count. With this technique, it is not possible to assure that all pulses are being tracked on the third cycle, but only that they are being tracked on an identical cycle. That is, all pulses tracked on 4th, 5th, etc. cycles. The addition of circuitry to identify the third cycle of the Loran-C pulse based on the shape of the pulse envelope would eliminate this problem. Such circuitry to identify the third cycle of the Loran-C pulse based on the shape of the pulse envelope would eliminate this problem. Such circuitry could be implemented through the use of a simple envelope derivation circuit, or through the use of analog-to-digital converter and software which would cross-correlate the received pulse envelope against the transmitted model.

5.3 True Multiple Target Tracking

The present DALS configuration uses the AIDS code to initiate a remote track and a change in AIDS code to abort the present track and to commence with acquiring a new retranmitter. The function of the AIDS code could be expanded to provide for a true multiple target tracking capability. In such a scheme, an AIDS code and the time differences associated with the transmission would be stored in the table designed to hold some maximum number of retransmitters. Upon the initial receipt of an AIDS code, the oldest retransmitter information in the table would be discarded

and replaced with the new code and the corresponding position in terms of tracking parameters (TOA values with respect to local). As successive AIDS codes were identified, additional values would be added to the table. Whenever a change in AIDS code is detected, the computer would first search the table to see whether it had previously tracked that retransmitter . If the value was already in the table, it would extract from the table the last known TOA values for the retransmitter and start tracking from tha point, checking to make sure that signal was still available in that position. Such a capability would enable the DALS to jump between multiple targets with a minimal signal acquisition time.

5.4 Use of DALS Display Technique With Stand-Alone Navigation Receeivers

The DALS receiver may be thought of as two combined systems:

- A tracking and identification system
- A positioning and display system.

By eliminating the DALS tracking hardware, the system may be reconfigured to accept time differences retransmitted to it from remote stand-alone Loran-C and/or OMEGA navigation receivers. Such a system would retain the sophisticated DALS plasma display capability without modification.

5.5 Improved Geodetic Positioning Computation

The present DALS software takes the tracker smoothed phase and time difference values and applies them to the geodetic routines without further filtering. This scheme may be improved by adjusting the DALS tracking system parameters to provide a sequence of nearly independent measurements each measurement cycle, and modifying the geodetic software to cause the geodetic interpretation of these points to be fit to a Newtonian mechanics model of the vechicle position. For example, the successive geometric points developed from the DALS tracker to be used to fit a track of position in time which allows for a vehicle with a maximum dynamics corresponding to a change of rate of acceleration.

5.6 Non-DALS Uses

The use of the DALS as a generalized phase measurement instrument suggests applications beyond Navaid tracking systems. For example, the computer/ comparator card combination could be configured to perform PSK data demodulation and radio direction finding.

APPENDIX I

GENERAL INDEX OF TECHNICAL DOCUMENTATION OF THE DISTRESS ALERTING AND LOCATING SYSTEM

VOLUME I (consisting of one binder) SYSTEMS MANUAL

I. Overview of Documentation

II. DALS Background

III. Capabilities of DALS

IV. System Hardware

V. Overall System Signal Flow and Signal Processing Techniques

VI. Additional Capabilities

VII. Loran-C and OMEGA Navigation Systems Background

VIII. Bibliography

VOLUME II (consisting of nine binders)

1. Introduction/Guide to Components

    A. Telemetry Sub-System

    B. Power Supply Sub-System

    C. Signal Mainframe Sub-System

2. D. AIDS Decoder/Display Sub-System

    E. Monitor Control Sub-System

3. F. Navaid Analyzer Sub-System

4. G. Translator Sub-System

5. H. Retransmission Sub-System

    I. Cassette Sub-System

    J. Teletype Sub-System

6. K. Plotter Sub-System

    L. Display Sub-System

☆ U. S. GOVT. PRINTING OFFICE 1977 701-312 # 79